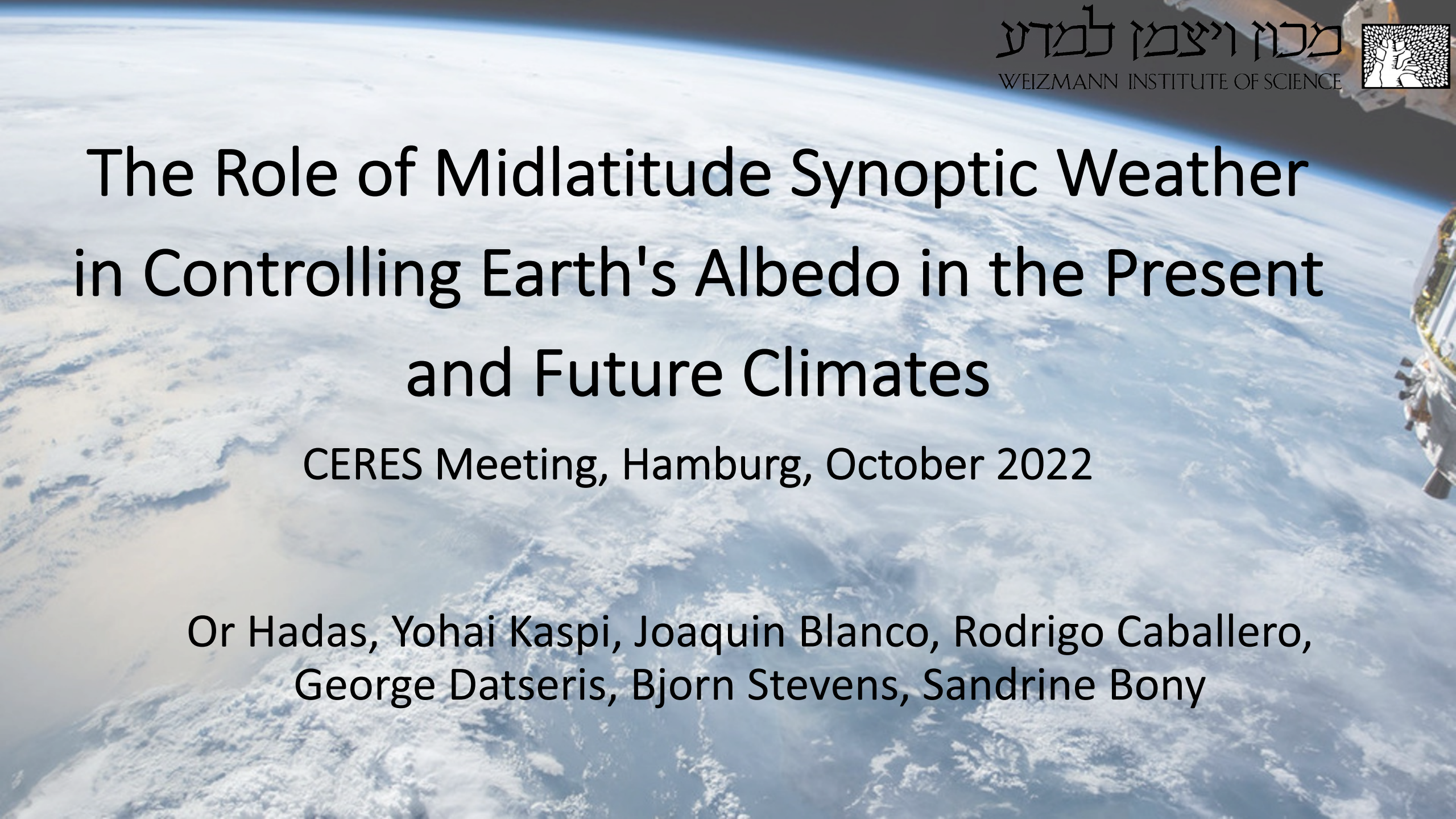

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

The Role of Midlatitude Synoptic Weather in Controlling Earth's Albedo in the Present and Future Climates

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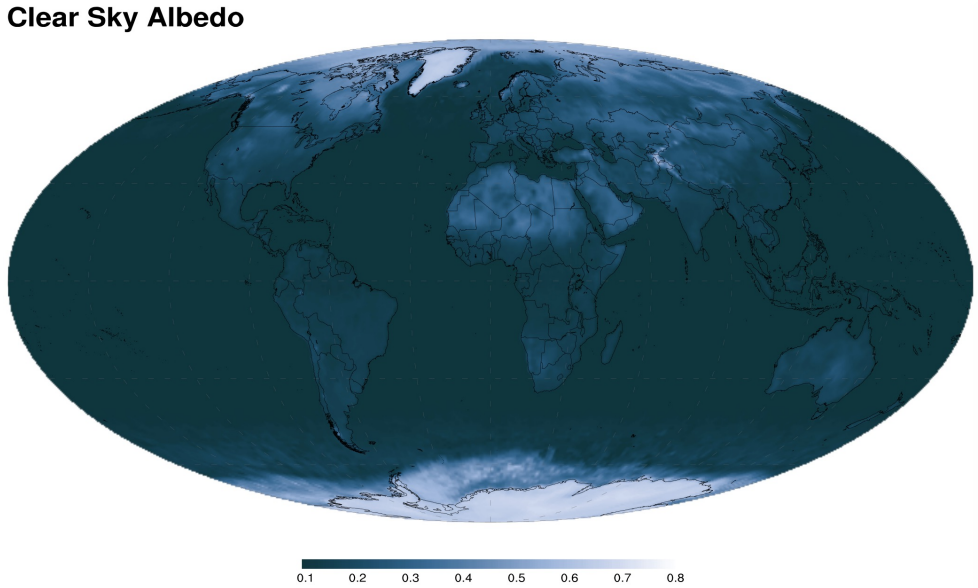
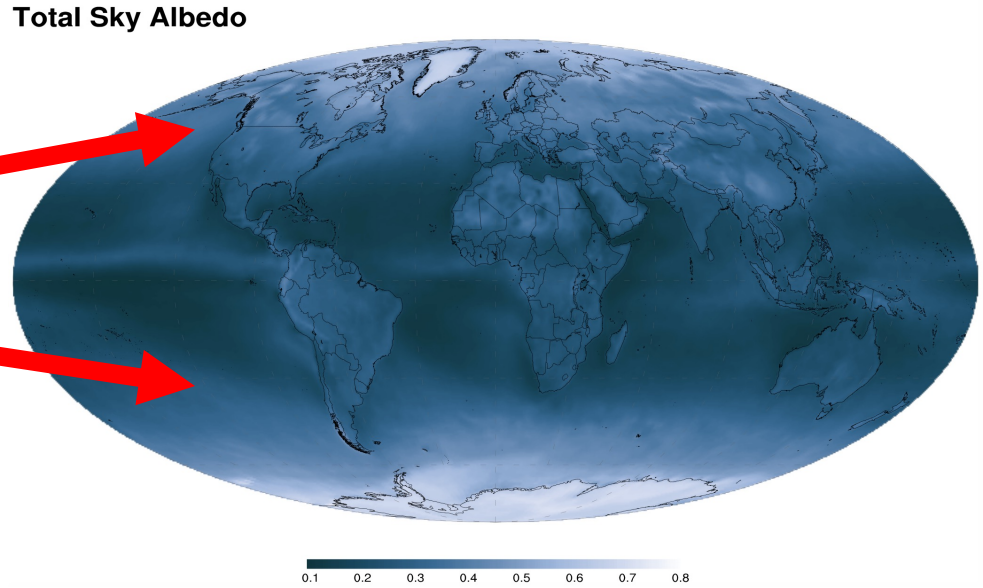
Albedo symmetry

- The NH clear sky albedo is higher by 11%.
- Balanced by a higher cloud albedo in the SH.



Same Albedo



From: CERES-Aqua

Cloud albedo

- We calculate cloud albedo based on CERES SYN1deg Ed4.1 using (Datseris and Stevens 2021):

$$\alpha_{cloud} = \alpha_{atm} - \alpha_{atm/clear}$$

- The atmosphere's contribution to albedo is defined as:

$$\alpha_{atm} = \frac{\alpha - a_s t^2}{1 - (a_s t)^2}$$

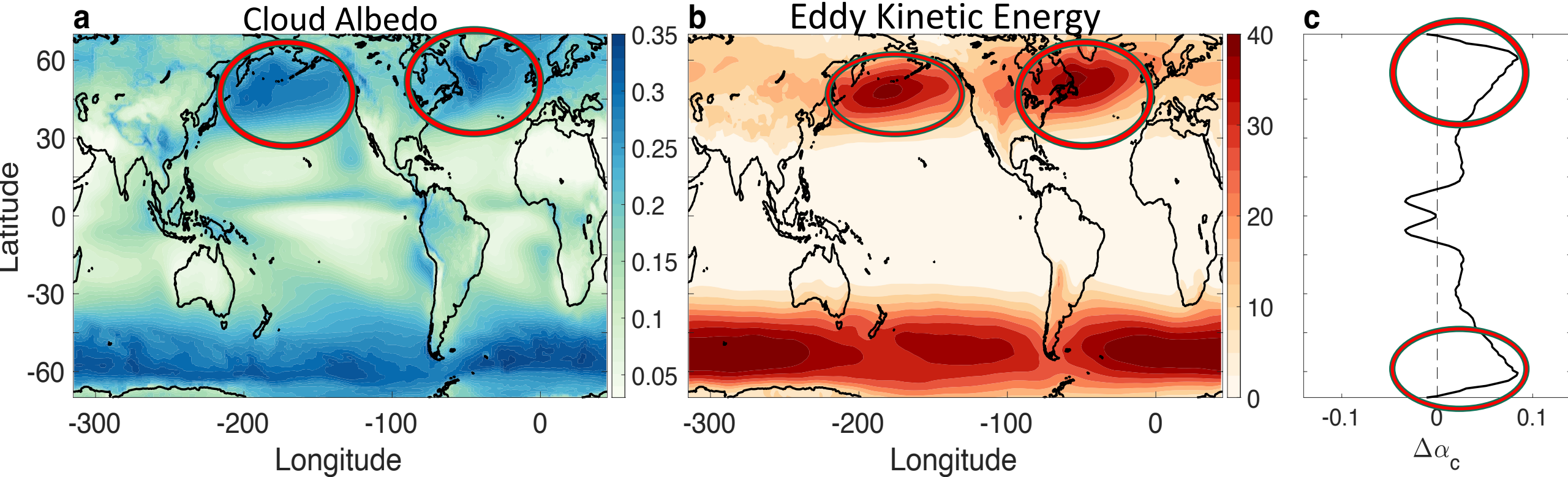
- Where:

$$\underbrace{\alpha = \frac{F_{\uparrow}^{TOA}}{F_{\downarrow}^{TOA}}}_{\text{Planetary Albedo}}, \underbrace{a_s = \frac{F_{\uparrow}^{SFC}}{F_{\downarrow}^{SFC}}}_{\text{Surface Albedo}}, \underbrace{t = \frac{F_{\downarrow}^{SFC}}{F_{\downarrow}^{TOA}}}_{\text{Transmisivity}}$$

- We calculate the albedo on a daily mean and interpolate it to 6h.

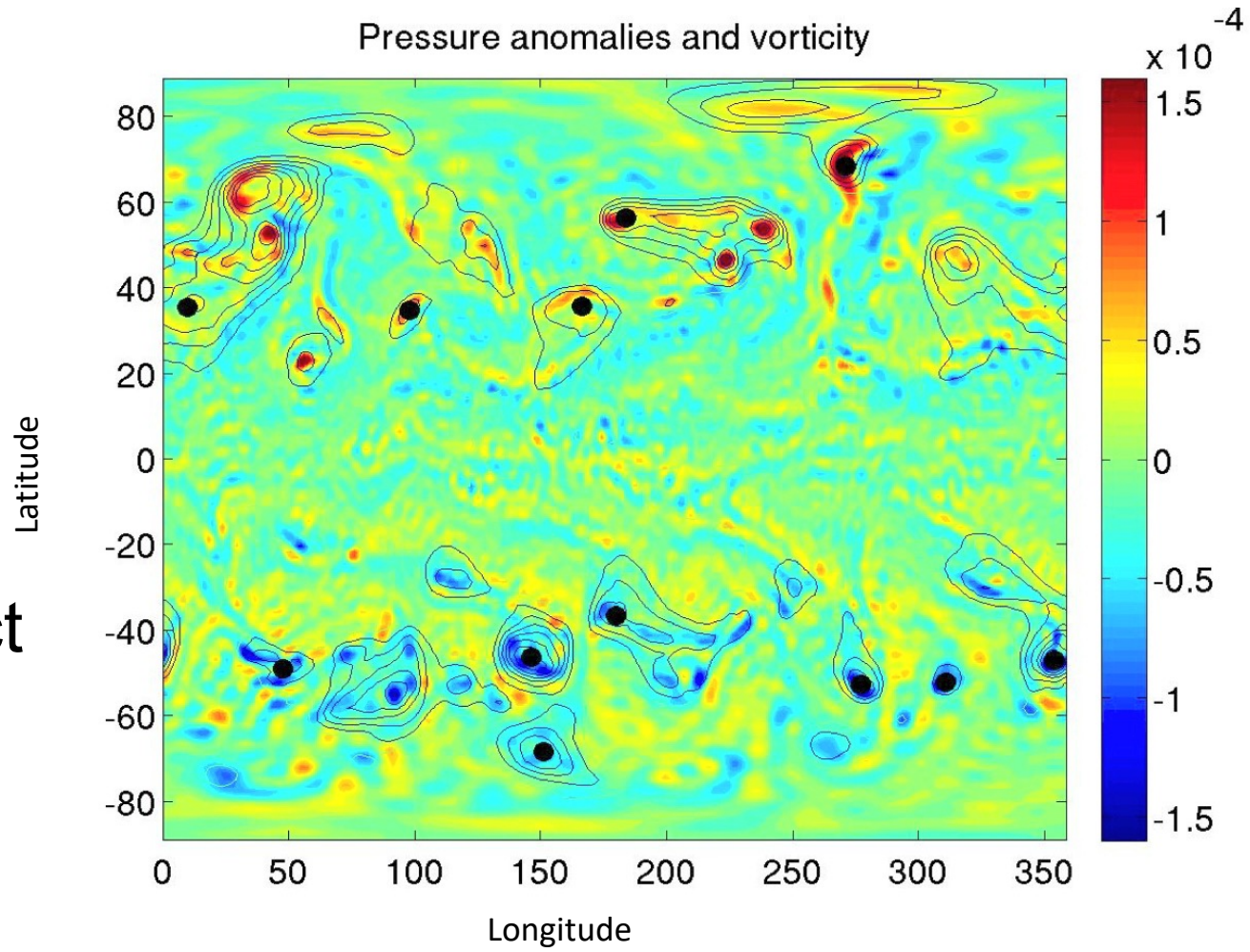
Albedo and baroclinic activity

- The midlatitudes drive the balance (Bender et. al. 2017, Datseris and Stevens 2021).
- Eddy kinetic energy and cloud albedo are highly correlated.
- **We propose that baroclinic activity mitigate cloud albedo and atmospheric circulation.**



Single weather system perspective

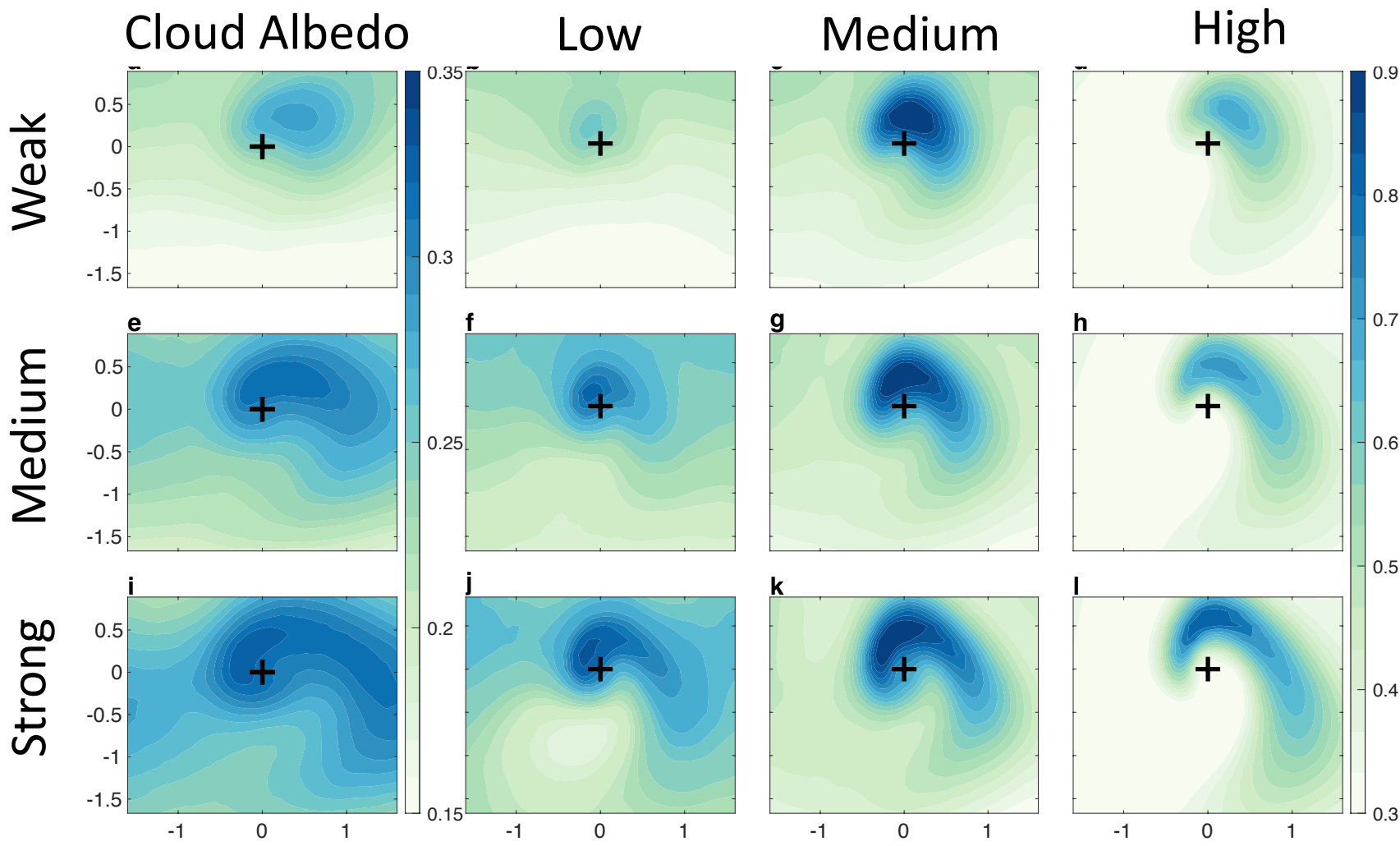
- A feature point tracking algorithm (Hodges, 1995).
- Identifies mobile features and tracks them.
- We track 6h ERA5 SLP data.
- The tracks, 6h cloud albedo, and cloud cover at different levels are used to make composites.
- This allows us to assess the effect of a single storm.



Single storm perspective, cyclones

- Stronger storms has higher cloud albedo.
- Due to more high and mid clouds in the warm sector.

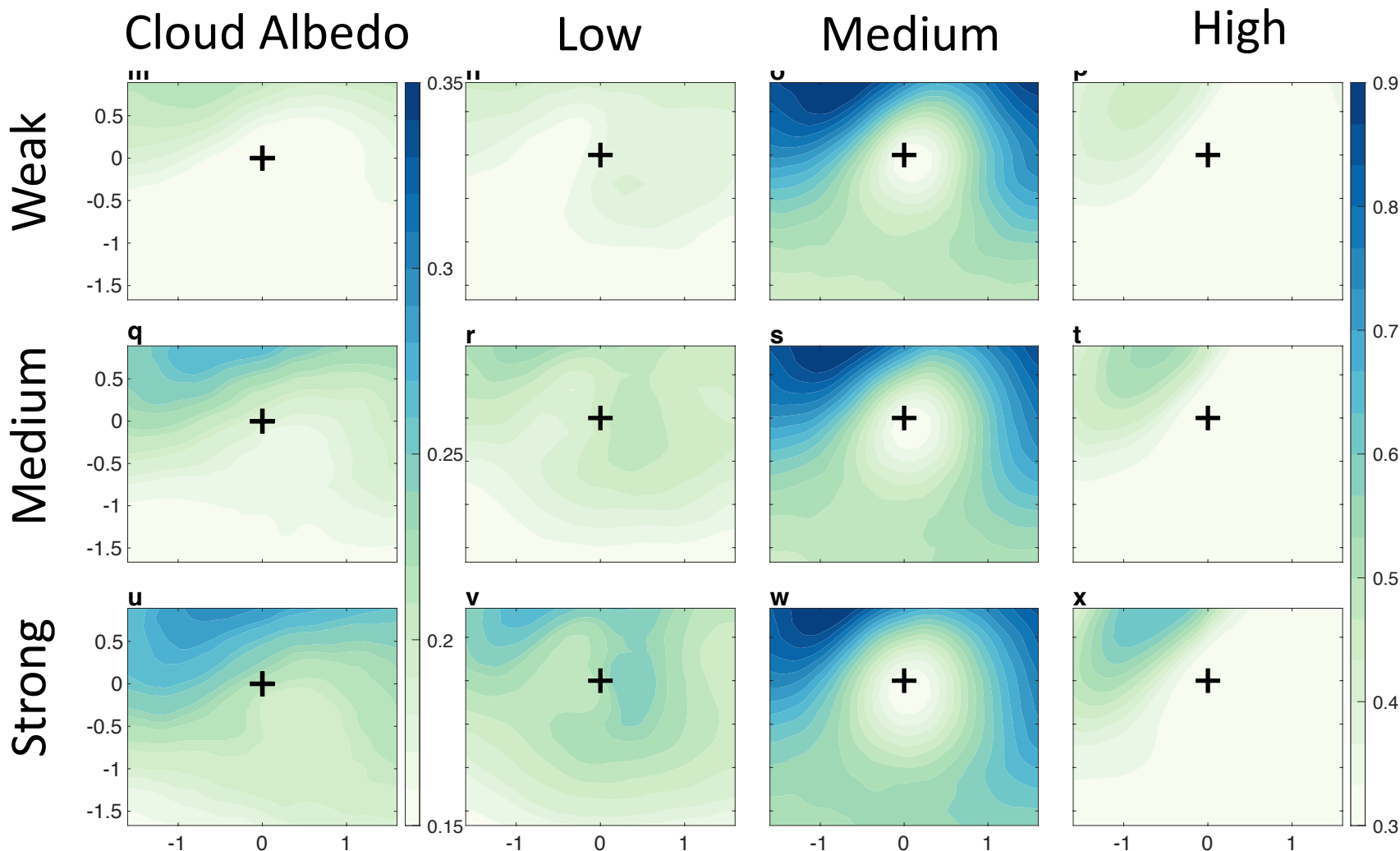
Weak: <40%
Medium: 40-70%
Strong: >70%



Single storm perspective, anticyclones

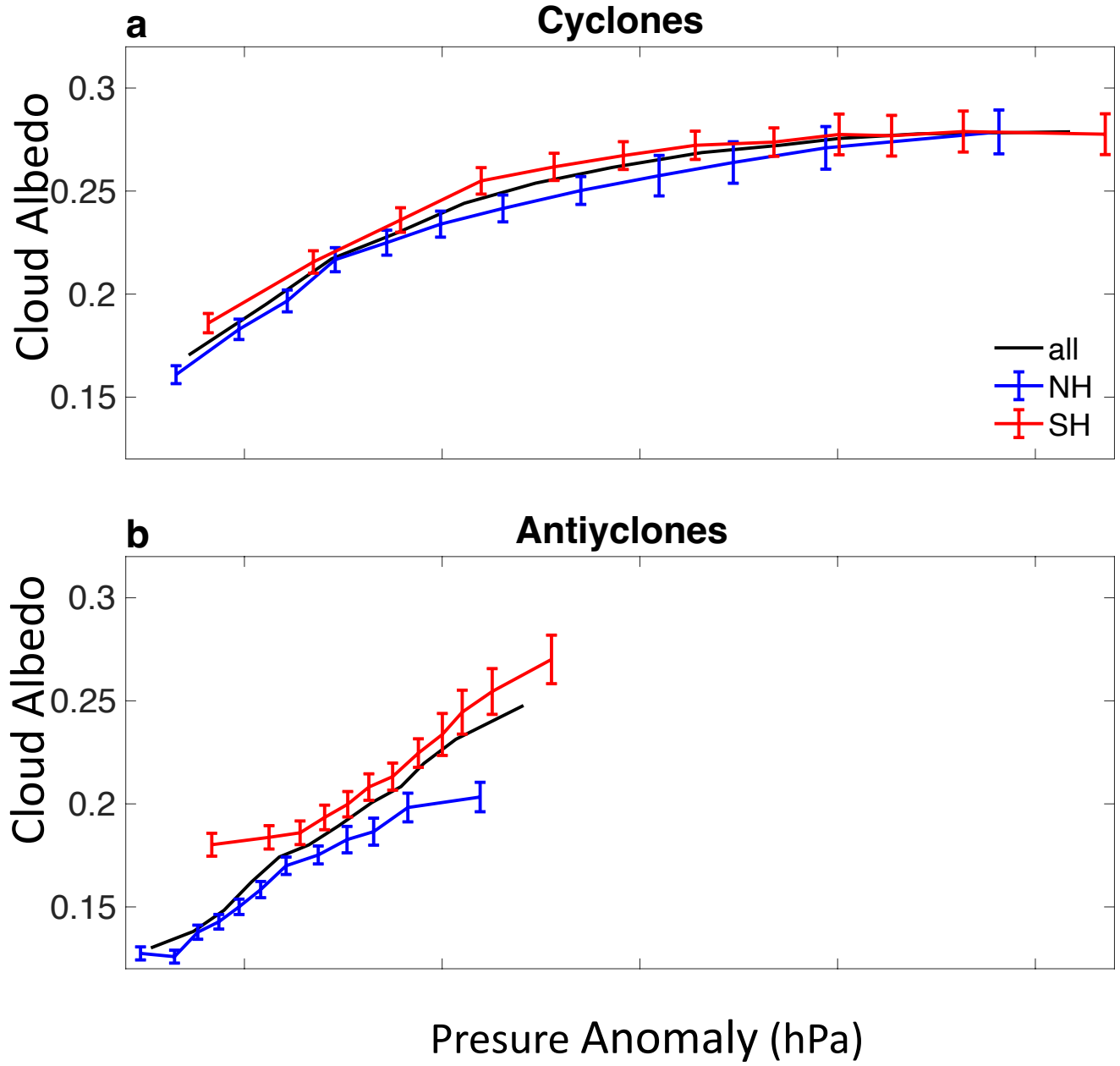
- Strong anticyclones are also cloudier.
- Due to more low clouds around the center.

Weak: <40%
Medium: 40-70%
Strong: >70%



Cloud albedo vs Intensity

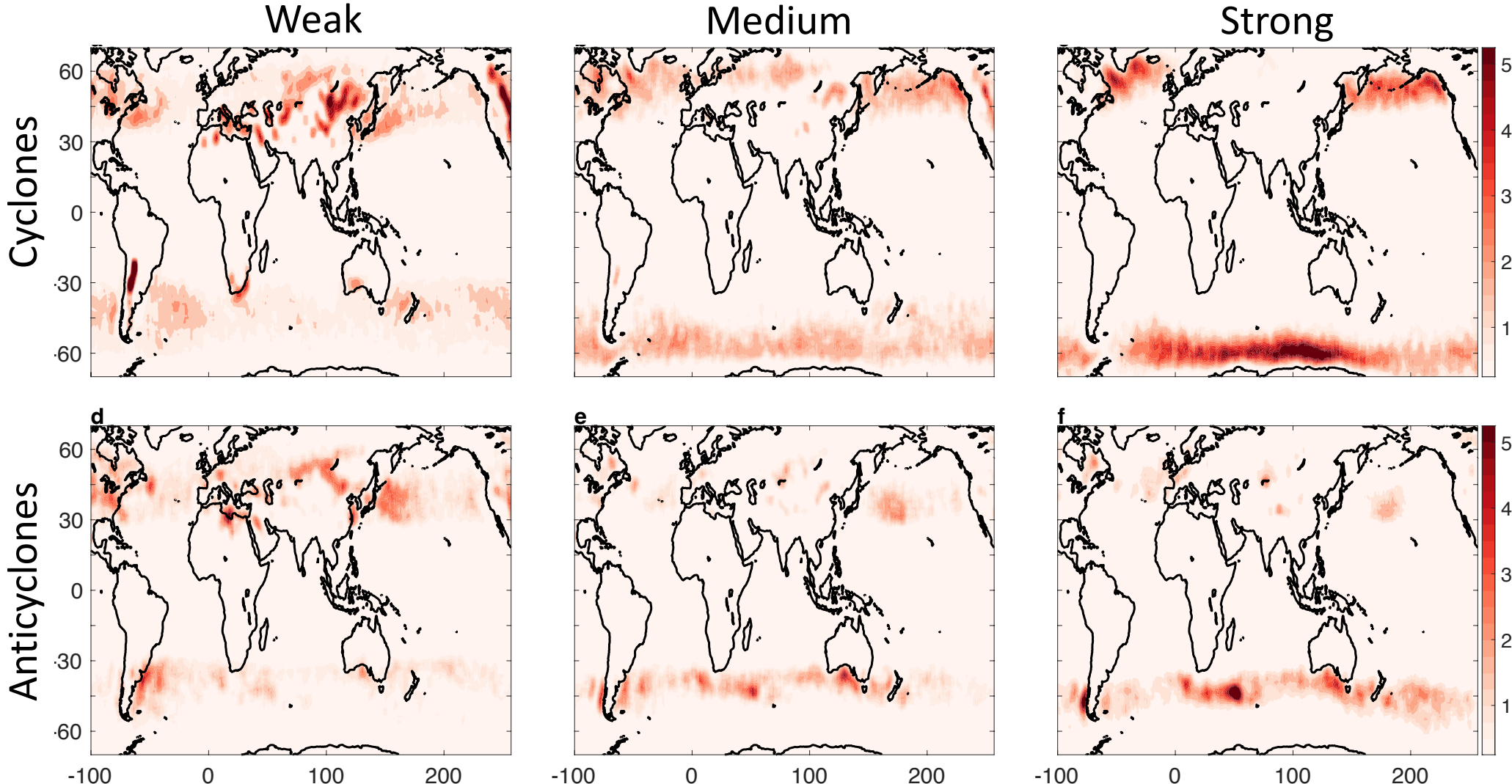
- Intensity is a great predictor for cloud albedo.
- Slight variation between the hemispheres.
- The curve saturates for strong cyclones.



Storm Distribution

- Weak synoptic systems are primarily in the NH and over land.
- Strong synoptic systems are mainly over the SH and Ocean.

Weak: <40%
Medium: 40-70%
Strong: >70%



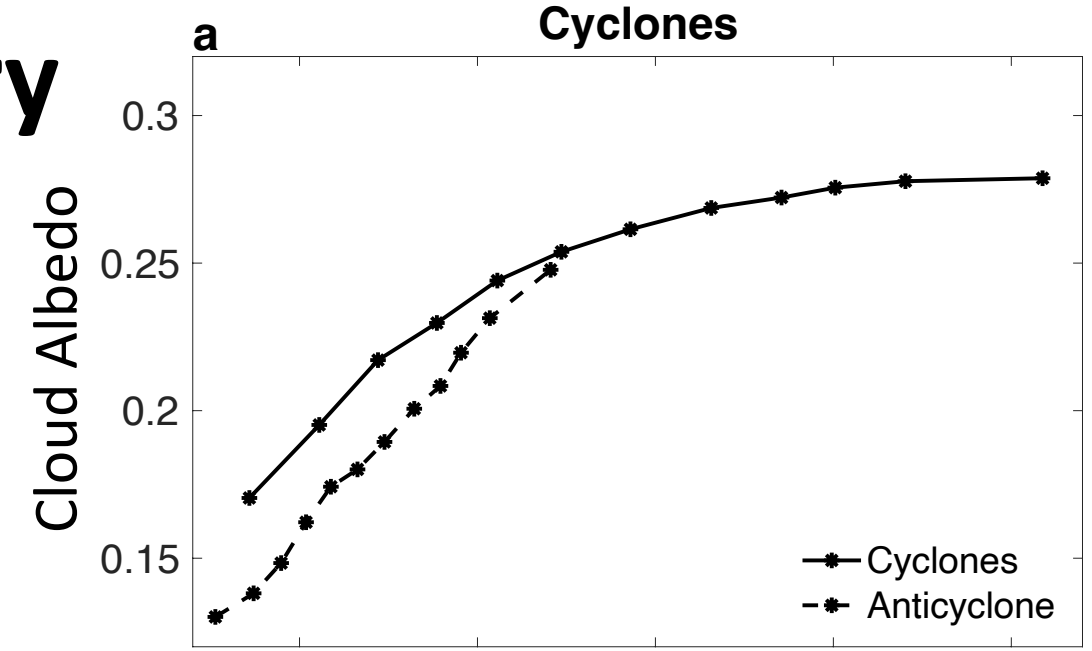
Hemispheric Cloud Asymmetry

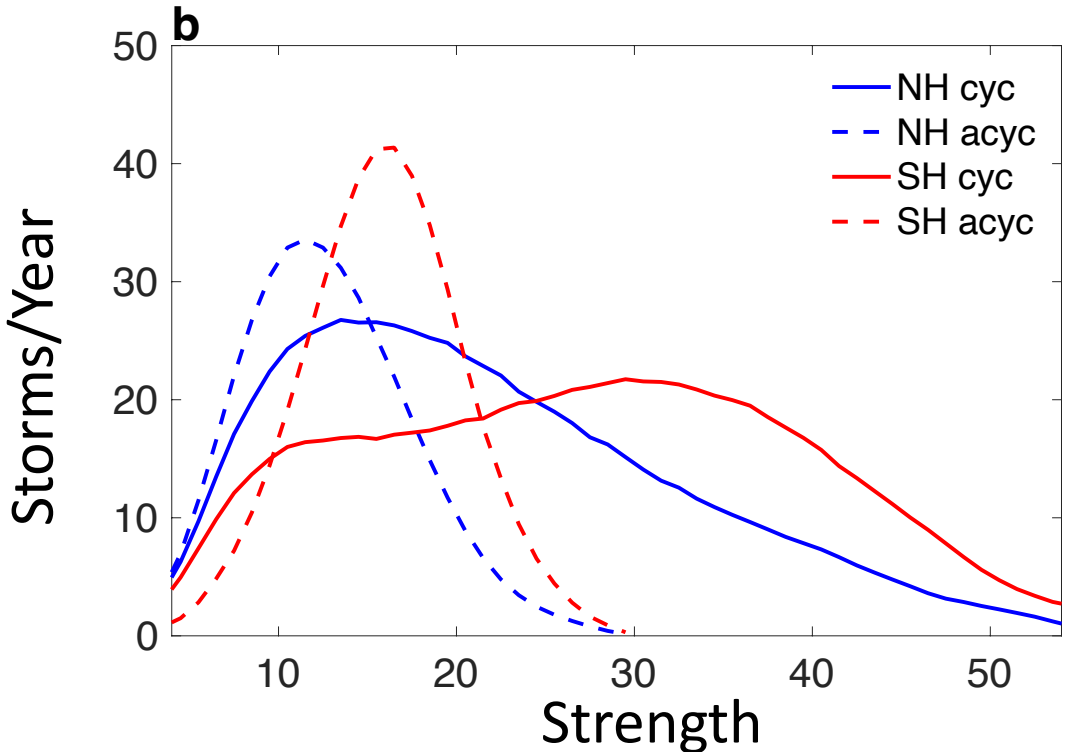
- Using these relations and the distribution of storms, we can calculate the expected difference in clouds:
  - Observed difference: 14.1%
  - Calculated difference: 15.7%

$$\alpha_{\mathrm{cyc}} \sim \sum_i \sigma(s_i) \cdot N_i$$

$$\alpha_{\mathrm{acyc}} \sim \sum_i \lambda(s_i) \cdot N_i$$

$$\alpha = \alpha_{\mathrm{cyc}} + \alpha_{\mathrm{acyc}}$$

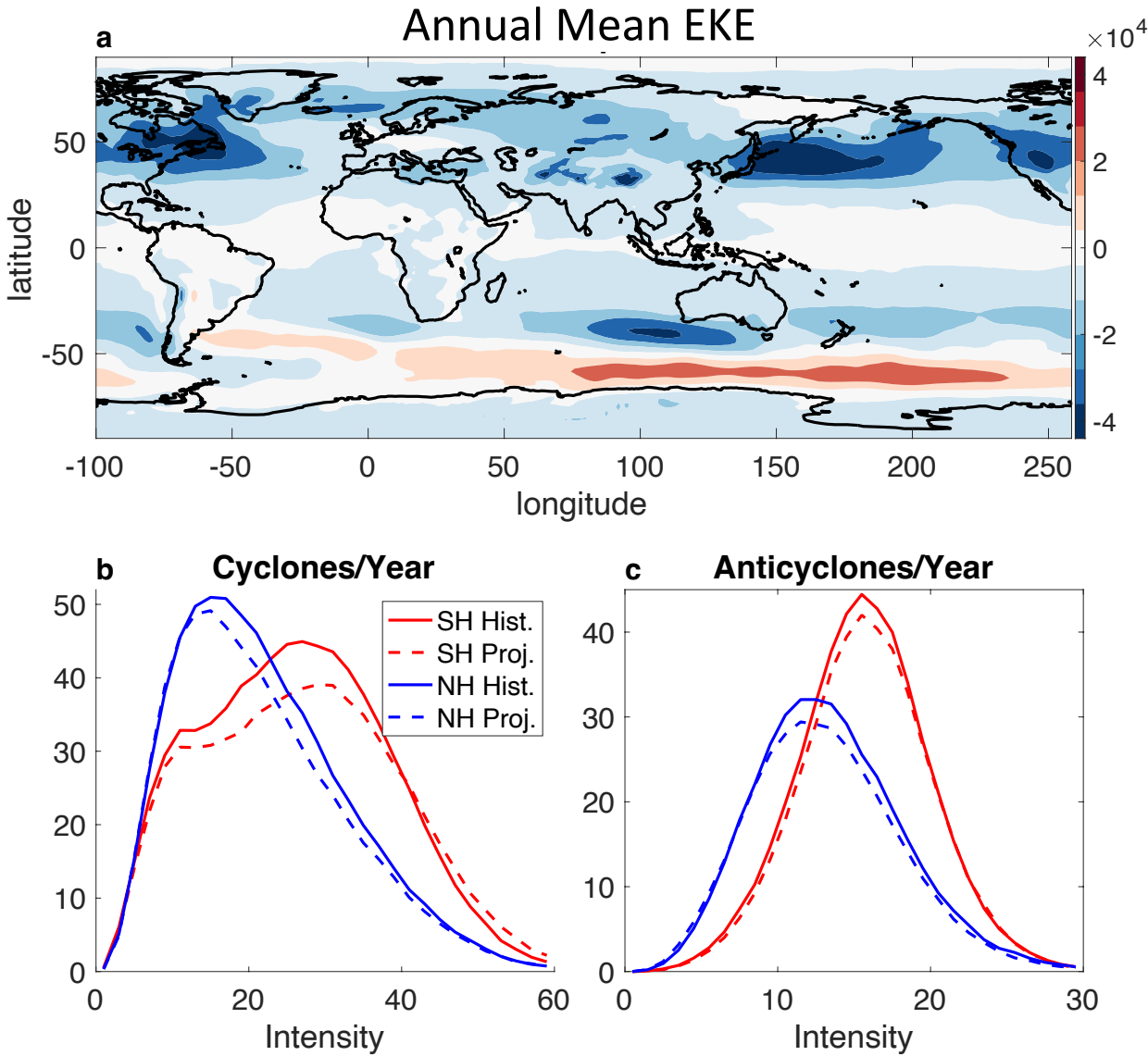




Hemispheric Cloud Asymmetry

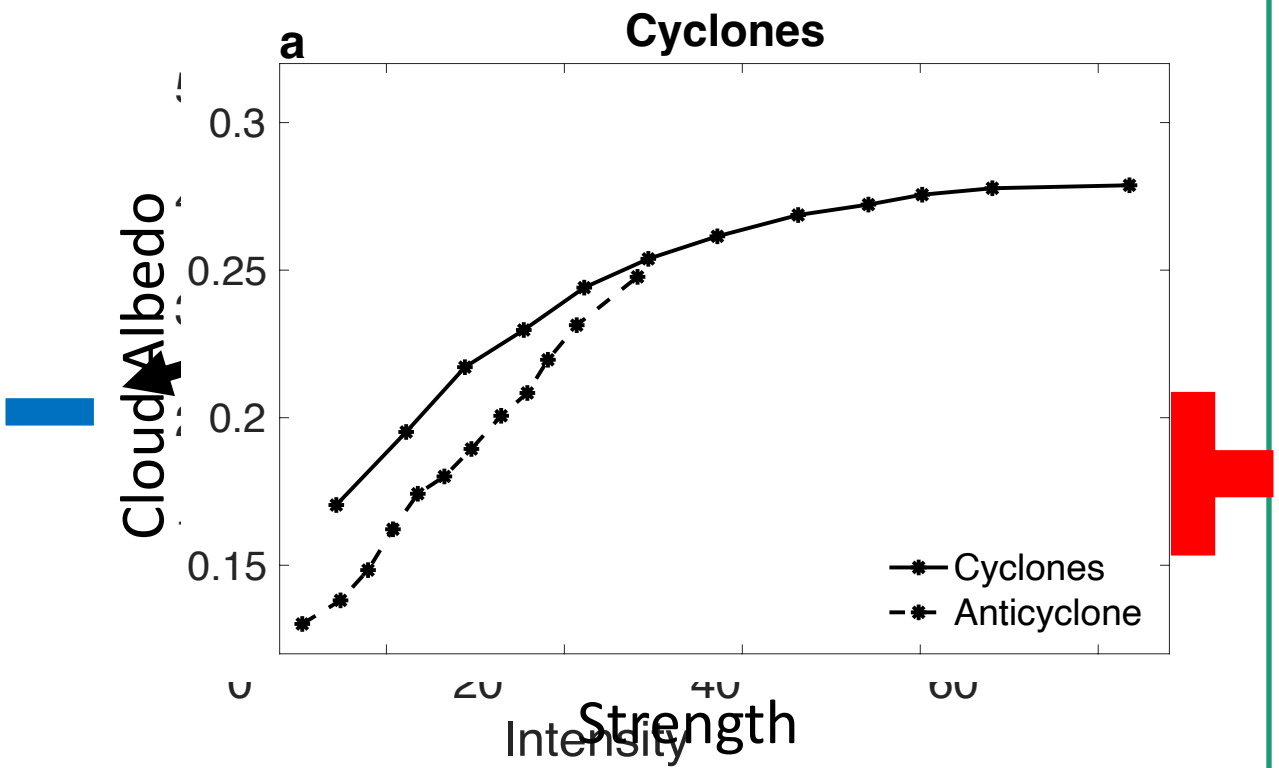
Albedo Symmetry in Future Climate

- CMIP6 prediction: stronger NH weakening.
- This allegedly means symmetry breaking.



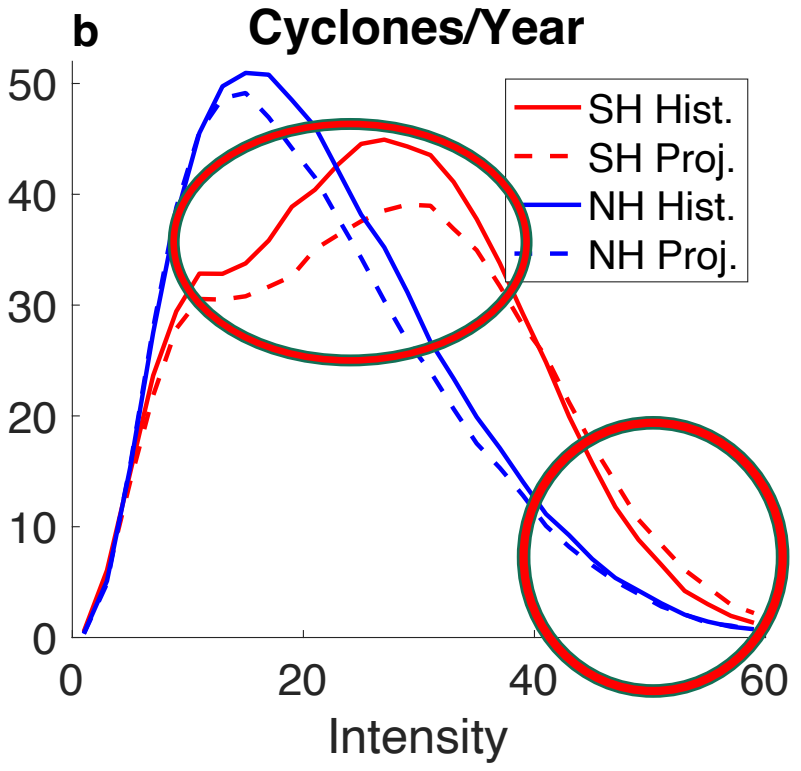
EKE

- EKE go like the intensity to the second power.
- Extreme cyclone has a very large contribution.
- No significant change is predicted.



Cloudiness

- Clouds saturate with intensity.
- A decrease of 7-8% is predicted in both hemispheres.
- **The symmetry is preserved.**



Conclusions

- EKE and cloud albedo are highly correlated.
- Strong baroclinic eddies are cloudier.
- The hemispheric difference in cloudiness can be predicted by the difference in storminess.
- We establish a causal chain between the assyemtry in layout between the two hemispheres and cloud assymetry.
- The CMIP6 storminess response predicts that this symmetry might persist in future climates.